SCIENCE AND TECHNOLOGY EDUCATION AND FUTURE HUMAN NEEDS

Bangalore Conference : August 1985

PRESERVATION, STORAGE AND FOOD SECURITY - A PERSPECTIVE OF FOOD SCIENCE AND TECHNOLOGY FOR FUTURE HUMAN NEEDS AND EDUCATION

S K MAJUMDER
Chairman, Food Technology Division,
Central Food Technological Research Institute,
Mysore 570013, India

The Committee on the Teaching of Science of the International Council of Scientific Unions
in association with COSTED, ICASE and Unesco

PRESERVATION, STORAGE AND FOOD SECURITY - A PERSPECTIVE OF FOOD SCIENCE AND TECHNOLOGY FOR FUTURE HUMAN NEEDS AND EDUCATION

S K MAJUMDER
Chairman, Food Technology Division,
Central Food Technological Research Institute,
Mysore 570 013, India

ABSTRACT

Agricultural development for the production of food has
ched its pinnacle of growth. Agronomical innovations have
n extended to major utilisation of arable lands and also
-arable lands. Imbalances of population growths in the
perate and tropical regions have been the major factors
the losing battle between food production and requirements
the population. The pockets of surpluses with the tradi-
nal agriculture and pattern of post-harvest processing
not meet the challenges of the next century. The changing
le of living, aspiration for higher standards of living of
sses, the trend of urbanisation, erosion of arable lands by
ressive dwelling have confronted the food scientists and
chnologists and also the sociologists, for seeking a new
ension to the future development. Calorie/protein balance
es not meet present human functional requirements.
ichiometric approach to food security is untenable in cost
logistics. Conversion and balancing of the present
ple foods like cereals and biomass transformation or
radation in plant and animal systems can only provide

future requirements. The advances in biotechnology, eco-oriented traditional food, the demand for quality of environment, purity and quality of food and energy consciousness, consumption and conservation have opened frontier areas of training and research. The future need, therefore, in education and training should include new curricula in the following fields, in addition to the basics being provided in the orthodox courses:

1. In High School System - Post-harvest Technician's Courses
2. In Pre-University Collegiate System - Post-harvest Technology Courses
3. In University Courses - Food Science and Technology
4. Post-graduate Research and R&D Institutions - Holistic approach and ecocompatible technology development

Some aspects of preservation, storage and food security systems are presented in this paper.

Perspective and Prologue:

The world population will double in every 35 years. It is apprehended that during the next 40 years the world will be faced with the extraordinary challenge of increasing food supplies at an unprecedented rate. There could be optimism only if the knowledge of improved advances in analytical methods and new fundamental knowledge regarding chemical and biochemical properties of plants and animals, of cells and

insects and of the microorganisms and enzyme systems that affect the productivity, is fully harnessed. The trained man power and resources at appropriate levels are required to adopt new methods and materials to local ecosystems.

Until the present era total populations of the world increased rather slowly due to the effects of war, disease and famine. The recent advances in medicine, food science and technology have reduced the ravages of diseases and have helped in limiting the incidence of starvation. The inter-disciplinery approaches to research in agriculture and food science can hardly be over emphasised in the light of present issues of human development. The grasp of the molecular world often provide the key insight and new approaches in biosciences and biotechnologies that multiply the effectiveness. The contributions of microbiologists, agricultural scientists, plant physiologists, plant pathologists, entomologists and others who are involved in the post-harvest conservation and processing are of profound effects in the augmentation of food supply qualitatively and also quantitatively. The translation of laboratory results into practical applications are beset with uncermountable problems of appreciation, understanding and applications between innovators and the agricultural users. The exchange of ideas and materials is synergistic and can benefit both the users and

the innovators. The current technologies of dissemination of science, computers and communication technologies have shown promise to bridge the gap of laboratory development and field applications. These aspects are not covered in the education as a general principle.

Profound differences exist from country to country in physical, cultural and economic and environmental features. These have substantial effects on the productivity and that contribute to the food supply system for human development. Global food supply and population are in balance. The current national boundaries dictate that the progress in food and agricultural sciences mostly require indigenous scientists to develop, adopt and apply solutions that might have originated endogenously or exogenously. The transfer of such technologie are beset with many problems with special reference to their logistics.

In spite of the pessimism the world food production has so far been able to keep pace with the population growth, atleast quantitatively. The disparities in production are principally related to local phenomena. The major countries of the world have given attention to agricultural productivity. The agronomic innovations and their applications have found place not only on arable land but also non-arable and marginal lands. Intensive agriculture with irrigation, fertilisers, pesticides and cultural practices have almost reached optimal

applications in most of the countries. Even the so called premitive agriculture is energy efficient in the new context of energy balance, energy management, out put in terms of natural calorie and consumable calorie. The food and agricultural education did not include these concepts.

Table 1

a) Commercial energy required for rice and maize by transitional and traditional methods

	Modern USA	Transl. Developing countries	Tradl. Developing countries	Modern USA	Traditional Developing countries
		RICE		MAIZE	
Crop					
Yield (kg/ha)	5,800	2,700	1,200	5,083	950
Energy/ha x 10^6 joules	64,885	6,386	173	30,035	173
Energy input (10^6 joules/kg)	11.9	2.37	0.14	5.91	0.18

Based on Pimentel el al, Science 182, Nov. 1973

b) Energy equivalents

1 kg equivalent	=	69×10^6 joules
1 lit of fuel	=	40×10^6 "
1 kg N-fertilizer	=	80×10^6 "
1 kg K-fertilizer	=	9×10^6 "
1 kg P-fertilizer	=	14×10^6 "
1 kg quality seed:		
- in the USA	=	30×10^6 "
- in a developing country	=	15×10^6 "
1 kg of pesticide	=	100×10^6 "

556×10^9	joules/worker in North America correspond to the largest cereal output of 67 tonnes/worker
8.6×10^9	joules/worker in Latin America correspond to the largest cereal output of 1.9 tonnes/worker 1.4 tonnes/ha.
0.8×10^9	joules/worker in Africa correspond to the lowest cereal output of 0.5 tonne/worker
0.8×10^9	joules/ha in Africa correspond to the lowest cereal output of 0.8 tonne/ha

Source: State of Food & Agriculture, FAO, 1976

The recent trend of urban migration from rural sector, which continues in most of the developing countries, has posed extraordinary dynamic problem of food supply, both in quality and quantity. The changing pattern of living style and aspiration for higher quality, the current food production is grossly inadequate in the regional perspective. The pressure of processing - raw grains into their refined milled products, fruits and vegetables in their highly or over processed materials; meat, fish and poultry to obtain over cooked selected products - has posed the problem of loss of nutrients due to over-processing and increase in wastage together with the wasteful high energy consumption. Thus, the pressure is due to the life style which is absolutely non-harmonious to natural balance. Therefore, the processing for so called purity and refined products has been responsible for imbalance in nutrition and even for the physiological acceptance in its metabolic train. The disturbances in the homeostatic limits and the imbalances in metabolism have been the results. These have led to the increased incidence of chronic metabolic diseases and neurological disorders.

The current Food Science education should include the concept of basic food, nutrition, hygiene, microbiology, entomology, biochemistry, mycotoxins, xenobiotics, toxicology, unit operations, machine design, systems of food conservation, food security and related aspects. These are to be taught for better understanding and perspective for optimum processing in the rural and urban harmony and milieu of social progress.

The new perspective of the education, training and research in the area of food science and technology, with special reference to preservation, storage and food security should have the following components:

1. Current problems of radioactive fallout and xenobiotics and its cycle in the environment, which include pesticides, fertilizers, heavy metals, mycotoxins, plastics and other manmade synthetic chemicals and related contaminants.

2. A relook of the traditional technologies, preservation and conservation techniques for their upgrading.

3. Integrated systems of food conservation with a special emphasis on safety of the environment and consumers and treating storage as a system in the entire spectrum of production, handling and utilization.

4. Frontiers of food conservation - basic biotechnology, molecular and genetic manipulation, flow cytofluorometry, neurophysiology of food components, etc.

1. Current problems of radioactive fallout and xenobiotics and its cycle in the environment, which include pesticides, fertilizers, heavy metals, mycotoxins, plastics and other manmade synthetic chemicals and related contaminants.

The geographical distribution of radio isotope, particularly the strontium (^{90}Sr) fallout, indicates extremely interesting trend: the biggest concentrations lie between 40°-50° latitude North and 40°-50° latitude South. The radio-active ions which enter the plant may get into the food chain, either directly or as plant products; subsequently, these enter animal food system. The cycle of radio active elements continue until decay. The radio strontium in food chain from natural sites to human body is an interesting phenomenon; like the pesticides the migration of radio nuclides follow identical pathways.

Plants that are prone to uptake and the plants that are weak with regard to uptake of radio active nuclides are being identified. Many of the above-ground parts of plants are responsible for ^{90}Sr and ^{137}Cs for their entry into food chain. The distribution is maximum on leaves, while the fruits and stems show comparatively less. Therefore, fodder is the major source of entry through the animal food chain. Similarly, the phenomenon of pesticide residues in food chain is now a part of the xenobiotic.

2. A relook of the traditional technologies, preservation and conservation techniques for their upgrading.

The traditional processes in food manufacture involve milling, germination, fermentation, cooking, dehydration and drying, granulation and extrusion. Most of these are directed towards the increasing storage characteristics and acceptability for consumption, particularly under a set of climatic conditions. The extent of loss in nutritive constituents depend on the type and degree of milling and processing. The extent of refining is done in modern mills, such as roller flour mill or solvent extraction plant, debranning and polishing systems, decreases many of the essential constituents. The fermentation processin traditional practice tends to increase the important nutritive constituents, improve digestibility and promote biosynthesis of essential food items such as vitamines, thereby the nutritive value of the products are upgraded. Germination as a pre-processing can improve the acceptability of the products, even more important is the biosynthesis of vitamins and increase in nutritive qualities and food assimilation. Availability of many nutritive and essential materials are augmented with the type of fermentation processes. In spite of their merits such products manufactured in traditional home-scale do not find national marketing channel. With the urbanisation, manufacture of traditional foods through upgrading of technologies without affecting the nutritional and organoleptic qualities are becoming imperative.

3. Integrated systems of food conservation with a special emphasis on safety of the environment and consumers and treating storage as a system in the entire spectrum of production, handling and utilization.

The developing countries are largely situated in the tropics and sub-tropics. In these countries, major intake of calories comes through cereals. The eco-systems provide optimum conditions for the growth of insects, moulds, rodents and elaboration of toxins by the activities of insects, moulds and mites. Basically the disinfestation and storage systems in post-harvest period with an understanding of the origin and source of infestation should include features like:

a) Freedom from infestation, from within seed or grain, and

b) The effectiveness of the treatment to prevent cross-infestation. Thus, the prophylactic and curative measures are required for conservation of foods.

In order to fit into the interfaces and interphases of agricultural and post-harvest systems, integrated application of the following techniques and products are appropriate and will be required to prevent bio-deterioration at all stages of production, processing, handling, storage and distribution (Majumder, 1970). At the same time, it would minimize the risks of pesticide or other contamination of food and pollution of the environment.

I. RURAL SECTORS

(a) Pre-harvest prophylaxis by spraying of:

(i) malathion or bromophos formulations on grains or pods or synthetic pyrethroids or primiphos methyl prior to maturity and harvesting of grains.

(ii) bacterial insecticides on paddy and vegetables.

(b) Field drying and processing:

(i) field drier, crib drier and algate drier;

(ii) maize hand-sheller;

(iii) groundnut and paddy drying of haulms and stalks, respectively;

(iv) control of fungi on wet harvested grains.

(c) Rodent control in the field with liquid fumigant emulsions and protecting the crop with high-viscosity rat repellent formulations.

(d) Insect-proofing and rodent-proofing of structures.

(e) Insect-proofing of gunny bags.

(f) Rodent control techniques for dwellings; repellent spray, primate-safe baiting with optical attractants for rats, trap-cum-baiting stations, fumigation of burrows with fumigant emulsion or liquid fumigants and detoxification of spent poison baits.

(g) Spot fumigation with liquid fumigant and fumigant ampoules, fumigant tabloids, fumigant cream.

(h) Incorporation of activated kaolin in raw pulses and other legumes' seeds for limiting intergranular space.

(i) Introduction of multi-purpose prefabricated unitized gasketed panel structures suitable for storage and gaseous disinfestation as composite part of rural homes.

(j) Institution of rural disinfestation services for curative and prophylactic treatments in the pre-harvest and post-harvest phases of crop production/utilization systems.

The above techniques, which have already been standardized and tested in the tropics, could cover upto 70 per cent of all food-grain production in a country like India. Such pre-harvest and post-harvest integration of disinfestation techniques in the rural sector has the possibility of augmenting food and nutrition supplies to a significantly larger extent than any other effort from existing production.

II. URBAN AND HOUSEHOLD SECTORS:

(a) Warehouses

(i) 'Durofume Process' that includes a tropicalised fumigant (ovicidal, larvacidal, pupacidal and cidal to adult stage of insects with a vapour pressure 1000 mm Hg. at ambient temperature and least reactivity with food constituents) for disinfestation and prevention of cross-infestation with high-viscosity insecticidal treatment of stacks;

(ii) 'Ballooning Technique' for storage of moisture-sensitive commodities that prevents ingress of moisture from humid atmospheres;

(iii) Rodent-proof design of storage structures.

(b) Food-processing Factories and Mill Sanitation

(i) Heat (Solar & IR) disinfestation for processed dry products and entolation of milled powered products;

(ii) Serial fumigation for inpackage disinfestation and intra-package injection fumigation;

(iii) Nutritional grain protectants (Tricalcium phosphate + Vit formulation) for inducing immunity against insect attack by selective metabolic aberration of insects;

(iv) 'Multiple Fumigation Process' for mixed commodities in large warehouses;

(v) Insect and rodent proofing of cartons and packages by repellent formulations for dry foodsand macaroni;

(vi) Dehydrobin principle to mitigate moisture condensation in small and large metal bins during storage of grains;

(vii) Laminated pouches/cartons for functional properties;

(viii) Silo-cum-elevators under large mill and bulk handling conditions;

(ix) Air curtains in warehouses and processing plants

(x) Entomological sanitation of surroundings.

(c) Household:

(i) Decontamination of fruits, vegetables and grains from pesticide residues;

(ii) Household spray emulsion and sprayer, repellent spray for domestic pest control;

(iii) Spot fumigant tablets, paste and powder for disinfestation of rations in domestic store;

(iv) Calcium phosphate-based grain protectants for long-term storage of milled food grains, and processed and formulated products;

(v) Pyrethroid/Bromophos formulations for store, kitchen and toilets;

(vi) Anti-termite pre-construction and post-construction treatments with newer termitical products;

(vii) Flyproofing/mosquito proofing using mechanical or chemical methods;

(viii) Vector control methods for controlling flies, mosquitoes, etc., with bacterial pesticides and other biological control methods.

The development of pesticides as related to its prodigeous growth of the industry during the last four decades since the advent of organo chemicals such as organo chlorine, organo phosphorous and organo carbamates has brought in the problem of their toxicities to various kinds to flora and fauna, and man and his environment. The future trend should be to mitigate these problems by holistic and well integrated view of the disciplines involved and of the ecosystem of which man - social, political and industrial man - is a part and parcel. The training should provide the synthetic and interdisciplinary approach and make the students in this field confident to solve problems in harmony with the ecosystem.

4. Frontiers of food conservation - basic biotechnology, molecular and genetic manipulation, flow cytofluorometry, neurophysiology of food components, etc.

(i) The food conservation has been the endeavour of mankind since the dawn of civilization. Post-harvest milling, processing and cooking were the earliest innovations for preservation, conservation and utilisation. The traditional foods, even in the developing countries such as the Kimchi and Kochujang of Korea, Gungru of Nepal, Tempe of Indonesia, Sourkrat of East Europe, Onchom of Indonesia, Mahuro of Philippines; Idli, Dosai and Dahi of India; Moi-Moi, Kishra, Gari, Ovi and Uji of Agrican countries and Soya sauce of China have been known to the World.

In these traditional processes, even the millets and casava, which are basically nutritionally deficient in quality, have been upgraded. Biosynthesis of carbohydrates, fat, increase of protein and augmentation of vitamins have been the part and parcel of the traditional processing and fermentation of the early times. Further, the storage as a system as evolved from time to time got disrupted due to the stratification of rural and urban developments.

(ii) Inherently the raw material comes from the field grown in the rural environment. The principle of pre- and post-harvest interphase and the threshold have been somewhat neglected. Both raw grain and the processed food fractions

are stored and utilised. Even a simple grain like paddy, provides straw, bran and the polished rice. A crop like sugarcane possesses enough biomass for entire energy requirement for processing to sugar, molasses and even to alcohol in the bagasse. Therefore, there is a need for providing attention to each component of the crop, not only for processing but also for storage and utilisation. Diversification of the main milling process for utilisation of the minor by-products and waste products could provide not only the security but also the favourable economics to the farmer. The future educational courses, therefore, should have a new dimension to food security. The integral principles should be:

(1) Dynamics of food budgeting for nation and world population.

(2) Conservation of food through flora-fauna as a food chain transformation.

(3) Upgrading of the fermentation and related processes.

(4) Shelf-life and storage through processing and controlled environment.

(5) Recycling of wastes such as field-trash, refractions, warehouse sweepings and processing gleanings or trimmings during handling.

(6) Mixed farming as a technology in the food security system - the balance between crop and animal production.

(7) Concept of energy chain and the management in all the above phenomenon.

(iii) New trends towards a new pattern of food protection and conservation:

The old knowledge through text books is not adequate enough to cope with the complexities of future requirements. Therefore, the basic policy should be that the training should be more in terms of comparative biology rather than taxonomy, physiology and related courses. The comparative biology must include morphology, physiology and biochemical specialisations and the immunology aspects, which should deal with their specific utilisation for conservation, both in vitro and in vivo. Curious phenomena have been observed in the physical limits of insects, moulds, mites, rodents and organisms responsible for biodegradation. A simple example is that comparative biology could teach us that the intergranular space is a limiting factor for growth of the specific pest for storage of pulses and legumes. The oviposition characteristics of insect pests, both in the field and in post-harvest grain storage, the semio-chemicals and pheromones, repellents and attractants, growth regulators, pest-management dynamics are newer boundaries in the field of food conservation and food security.

(iv) Food in purest form is quite harmful. A chemically defined food like pure protein, pure starch, pure fat and so on do not find place in the balanced nutrition. Aberrations in nutrition do occur in such pure food consumption. In current years, addiction and affinity (dependence), immunological

stresses and allergy manifestations are recognised as the results of imbalanced pure quality food intake and xenobiotics in foods. Therefore, the balance of individual constituents in cereals, pulses, oil-seeds, animal products are the matter of great research endeavour, not only for in vivo utilisation and conservation but also their efficient role in the food security system. Selective protectants and additives are the results of understanding of evolutionery physiology, immunology, biochemistry, morphology and taxanomy. The future role of these in food conservation cannot be overemphasised in view of their beneficial role in environmental protection, food safety and balanced nutrition.

(v) The food system cannot be taken in isolation. The knowledge of the following fields will be the future need:

(a) Xenobiotic cycle.

(b) Holistic approach for designing a new technology, i.e., the food system inclusive of security must imbibe the food chain - trophic system, and niche of the new technology in total social parlance and eco-system.

(c) Abatement Science, its development and application should be the attitude for pollution management rather than monitoring to present a pessimistic or horror picture.

(d) Development of redeeming technologies for decontamination of soil, air, water and food in contrast to monitoring and surveys.

(e) Technocracy as a factor in rural development to reverse brain drain from rural to the urban areas.

(vi) Animal production and poultry is not conventionall looked into as a reservoir of foodgrains. The energy and biomass conversion basis in animal system had been usually taken for computation as a negative balance. There has been an attempt by Dr.B.L.Amlato approach the food security problem from a total integrated point of view (personal communication). The animal conversion can be looked upon as value added product and also during the process it serves as employment generating source. During the growing of the animals the profitable job of the farmer and his family members should be regarded as an out-put along with the in-puts. The dynamics of this integrated system needs detailed study of the energistics and economics. Therefore, the grain conservation, particularly the excess grain in a bumper crop season, which may not be accommodated within the capital intensive storage space of warehouse or silos (the new animal conversion system) could be looked upon as an additional dynamic process of storage while undergoing biological conversion. In the surplus economy of grains in a country the animal raising with cereal feed may have different context or connotation with respect to economy and utilisation. The inevitable losses are prevented and economic and social gains would need a relook on the grain handling system.

pilogue

The internal brain drain of the skilled technologically rained and persons with higher learning have gravitated owards the urban settlements. There is progressive depleion of such brain trust and skilled human materials from ural sector. This has prevented the development of self-mployed technocrat based industry for producing value added roducts using local agricultural resources. The training n the post-harvest conservation and utilisation of the raw aterials produced by agriculture as feed, food and fibre nd also other industrial raw materials should be the main im of producing the rural oriented technocrats. This eversion of the brain drain from the rural to urban for igrating from urban to rural sector can only be accomplished y an educational and motivated training approach. In this ontext, the future need, therefore, in education and train-ng should include new curricula in the following fields, n addition to the basics being provided in the orthodox ourses:

. In High School System -- Post-harvest Technician's Courses

a) Pre-harvest spraying and prophylaxis, equipment and application.
b) Threshing and solar drying.
c) Straw bailing technique.
d) Pest control : Rodent, Bird, Insect, Mold.
e) Crop Insurance.
f) Post-harvest processing, cleaning, grading.
g) Packaging and containers for storage.

h) Disinfestation and fumigation techniques.

i) Rural home and storage sanitation measures.

j) Fruit and vegetable preservation processes.

k) Seed treatment, protection and processing.

l) Feed processing.

m) Agro-mechanics (pumps, sprayers, tractors, threshers, winnowers, pest control equipment).

n) Bee-keeping.

o) Sericulture

p) Lac-culture

q) Animal/poultry/fish farming in 'trophic system' of raising

r) Kitchen garden pest control.

s) Rural Warehousing.

t) Expeller for oil extraction.

u) Sanitation, biogas, farm waste, energy utilisation for village home.

v) Solar energy concept.

II. <u>In Pre-University System: Post-harvest Technology Courses</u>.

a) Disinfestation service systems.

b) Biosciences (including entomology, plant pathology, microbiology, animal nutrition).

c) Mechanics & Mathematics.

d) Machine drawing & design.

e) Biometry & Statistics.

f) Workshop.

g) Chemistry.

h) Physics.

i) Sugarcane processing.

j) Oil seed processing.

l) Dal milling.

m) Activated clay, carbon and ash production - principles & processes.

n) Bacterial insecticide production.

o) Basic book-keeping & costing.

p) Seed production technology.

q) Cold and cool storage: principles, design and operation.
r) Warehousing.
s) Storage structures, handling systems and constructions -- (Ballooning, CAP storage, Silo, Godown).
t) material handling tools and machines.
u) Report writing and project preparation (small scale).
v) Banking and insurance.
w) Draughtsmanship.
x) Pesticide, Fertilizer, Growth Regulator - formulations.
y) Plant protection technology.
z) Rodent control, Mosquito control and Fly control -- integrated methods.
z1) Abbatoir management - sanitation & byproduct usage.

III. University Courses: Food Science & Technology

a) Rural anthropology/sociology.
b) Rural Economics.
c) Agribusiness.
d) Plant Protection Science & Technology.
e) Animal husbandry, production in ecosystem & animal products.
f) Land scaping, contouring, cartography.
g) Graphics, printing, layout of publications for extension literature and commercial art, photography, xerography.
h) Information sources in Food Science & Technology.
i) Unit operations and food engineering.
j) Safety, toxicology and behavioural assay.
k) Biotechnology, Biophysics and computer science.
l) Floriculture, Bonsui, Plant propagation and Greenhouse Technology.
m) Tissue culture & cell culture.
n) Biochemistry & molecular biology.
o) Statistics, biometry and mathematics of food processes.
p) Organic chemistry of pesticide and semiochemicals.
q) Pest Management, Protectants, Storage and Food Security Systems.
r) Cereal Science & Post-harvest Technology.
s) Oil Seed Technology.
t) Fruits and Vegetables Technology & Plantation Crop Processing.

u) Dairying & dairy waste conservation.

v) Institutional kitchen design, equipment and management.

w) Traditional foods, specifications, manufacture and quality control.

x) Enology and fermentation industry.

y) Fumigation science & controlled atmosphere technology.

z) Radiation preservation & biophysics.

z1) Quarantine, export quality control & contaminants surveillance methods.

z2) Planning of food industries complexes.

z3) Ecology, environment & xenobiotic cycles.

IV. Post-Graduate Research(M.Phil./Ph.D) & R&D Institution.

a) Interaction of Food Constituents in Cell biology, Tissue and Organ Systems, Nutrition and behaviour.

b) Food addiction, immunology and allergy inter-relationships in traditional diets and effects on health, performance and physiology.

c) Photo-autotrophic cell culture for production of primary products - food, feed, energy, bioactive industrial products, vitamins, enzymes, flavours,colours and others.

d) New requirements of downstream processes in biotechnology of submerged fermentations, live cell mass, viable biomass and biopesticides.

e) Xenobiotics and food constituents - interactions, antagonism, synergism, detoxification metabolism and longterm effects in vivo.

f) Elucidation and understanding the basic mechanisms in plant and animal cells, their metabolic regulations for enhancing shelf-life and storage of fruits and vegetables under tropical temperatures.

g) Biosynthesis and biotechnology of meat analogue from oil seeds, cell cultures and tissue cultures.

h) Energy nexus in post-harvest systems.

i) Food additives - its action on nutrition, neurophysiology and behaviour.

j) Cybernatics in post-harvest processes, technologies and food systems.

k) Greenhouse technology for plantation crops, spices, plant insecticides and plant drugs.

l) Sensory biophysics of ethnic foods - sweetners, salts, bitter and sour principles, chillies, flavours, colours, texture - their measurements, neurophysiology and thresholds.

m) Technologies and specifications of traditional foods - fermented and non-fermented products.

n) Operation research on packaging and transport systems of grains, fruits, vegetables, milk, fish, poultry and meat products to bridge farms and consumers.

o) Ergonomics, safety, convenience, efficiency and economy in socially compatible kitchen design, including structure and construction, store, oven, kitchenware, gadgets, tools, washing system and kitchen waste handling.

p) Post-harvest technologies in mixed farming systems for small farmers.

q) Animal, poultry, fish, biogas and feed biomass as integrated trophic system of production in rural homes for economy, safety and sanitation.

r) Eco-compatible abbattoirs for small and medium scale slaughter, by-product utilization and preprocessed or processed ready-to-use product manufacture.

s) Development of warehousing disinfestation, controlled atmosphere, storage and processing complexes for cluster of villages.

t) Mobile monitoring units for pesticides, heavy metal, mycotoxins in ruraland urban markets.

u) Decontamination processes and services for grains, fruits, vegetables and edible oils to reduce the contaminants to their safe limits.

v) Production technologies for new ecologically safe sanitation agents, specific pest control products, selective and non-toxic protectants for household storage and pest control in rural and urban homes.

w) Convenience foods, ready-to-serve products and instant foods based on traditional food formulations.

x) Agricultural trash and plant wastes for conversion to packaging materials.

y) Design of prophylactic diets for metabolic detoxification of xenobiotics, heavy metals, mycotoxins and procarcinogens.

z) Experimental basic of dietary protection with traditional foods, spices and related agents against circulatory, renal, neurological,allergic and metabolic disorders.

z1) Home-scale and traditional processing in nutritive qualities, organoleptic preference, culinary properties of food products (non-fermented and fermented).

z2) Industrial Entomology for production of food, feed, fibre, industrial chemicals and additives, bioluminescence and energy saving devices.

z3) Design and development of pre-processing & processing complexes for plant and animal products, including their by-product utilization, sanitation and recycling plants for cluster of villages.

Conclusion

The basic structure of food science and technology education should, therefore, have dynamic curricula with the changing pattern of the social evolution. The evolutionery trend in the education of food science and technology should inculcate innovation attitude to upgrade ecocompatible local products and incorporate sophistication in handling, packaging and presentation in consonance with the consumers' demand. The vital and more strategic need is the even distribution of food industries or post-harvest agricultural industries in the rural sector. Reversing the internal brain drain from village to town and promoting innovators to remain in their country of origin must be achieved in the third world. These countries are inherently situated in the tropical and subtropical belts of the world, with all the ecological problems, that are not profound in developed countries. The challenges are really exciting in Food Science & Technology for future human needs and education.

Acknowledgement:

The author is grateful to Dr.B.L.Amla, Director of the Institute for his interaction and encouragement.

Bibliography:

1. Amla,B.L. Personal Communication.

2. Pimental et.al. Science, 182, Nov. 1973.

3. FAO UN, State of Food & Agriculture, FAO, 1976.

4. Lofts, B & Chan, S.T.H. Biological Research in South East Asia. Occasional Publication No.3, Hongkong Univ. 1977.

5. University of Reading, Faculty of Science, Readg 78, Prospectus 1983.

6. Chemistry and World Food Supplies. Report of a Workshop. National Academy Press, Washington, D.C., 1983.

7. IAMR Report No. 1/1977. Manpower Development in Rural India - A Case Study. Applied Publishers Priv.Ltd. 1977.

8. Majumder, S.K. Protecting Food from Deterioration. Proc. 3rd International Congress of Food Sci. & Technol., SOS/70, Washington. 519-531. D.C. 1970.

9. Deosthale, Y.G. The Nutritive Value of Foods and the Significance of some household processes. Food & Nutrition Bull. Supplement 9, UNU 1984.

10. Majumder, S.K. Inter-relationship between Pre- and Post-harvest Production Systems. Proc. UNU Workshop on the Management of R&D Institutions in the area of Food Science & Technology, 1979, 17-26.

11. Majumder, S.K. Nutritional Implications of recently developed techniques of storage and pest control. UNU Food & Nutrition Bull. Supplement 9, 1984.